1. Introduction

This Technical Appendix is part of TRW's Reply Comments to the Notice of Proposed Rule Making regarding Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610-1626.5 / 2483.5-2500 MHz Frequency Bands (CC Docket No. 92-166). It addresses only those issues raised by the various interested parties in their Comments, which TRW considers need further explanation or discussion, and is not meant to be an exhaustive review of all the technical issues in this matter. TRW's views on issues not addressed here can be found in previous filings on this subject.

2. Non-Geostationary Satellite System Advantages

AMSC Comments

This section of the document addresses the claims made by AMSC in the Technical Appendix to its Comments, to the effect that geostationary satellites overcome many of the disadvantages of non-geostationary satellites in the provision of future advanced MSS services. In every case AMSC's argument is found to be invalid. Indeed, many of AMSC's arguments appear to be somewhat confused in their objective as they criticize aspects of the non-geostationary MSS Applicants' systems that would be common to AMSC's usage of these frequency bands. In many instances AMSC's criticisms imply, without a shadow of a doubt, that AMSC has no plans to offer, either now or in the future, a true hand-held MSS service operating in these bands. Instead, AMSC's logic concludes that it is better to use the subject frequency bands for an inefficient domestic-only MSS system that only operates with vehicular mounted MES antennas, and replicates a system already assigned significant spectrum for use in the USA, than to even attempt to create true hand-held MSS systems that work not only in the USA but throughout very large parts of the rest of the world also.

Each of the AMSC arguments made is addressed below:

Power Control: AMSC claims that CDMA power control will not work. Its suggestion that this was proven in US WP8D is simply not true, as a more detailed recounting of that record will show. Within the US WP8D discussions there was considerable debate on the topic of a proposed US contribution that reviewed how power control might be implemented in one of the proposed CDMA MSS systems (LQP). One of the techniques discussed was to use the S-band MES received signal level as a measure by which to control the L-band MES transmitted signal. It was pointed out that the poor correlation between the propagation characteristics at L-band and S-band would introduce considerable errors in some instances with this approach if it were the only means used to implement power control. However, there are other complementary techniques for implementation of power control in CDMA systems which were also discussed. One of these is a closed loop control system based upon link performance (bit error rate) measurement. It was generally agreed within the US WP8D that power control techniques could be adopted that utilize several of these techniques in unison, which would achieve the overall desired objective when aggregated over all the links within a channel/beam.

An interesting and very important inconsistency in AMSC's submission in this respect is that AMSC's Exhibit B[1] provides detailed arguments for the use of CDMA in a futuristic high performance geostationary MSS system, in preference to any FDMA or TDMA or FDMA/TDMA hybrid technique. Implicit in the use of CDMA is the implementation of power control techniques to avoid unnecessary spectrum saturation. How can AMSC on the one hand deny that power control can be made to work and on the other hand rely on it for a future GSO based MSS system?

Propagation Margins: The criticisms made by AMSC that non-GSO MSS systems cannot provide service to hand-held users, based on propagation margin requirements, is not substantiated. A few statistics have been cited by AMSC, which do not provide the full picture. In particular, the ODYSSEY system design ensures significantly higher elevation angles to the satellite that any of the other proposed non-GSO MSS systems. This in turn drastically reduces the propagation margin required, as demonstrated by the Motorola propagation data cited by AMSC. AMSC also ignores the very important advantage of a CDMA system in this respect, which is that the average propagation margin across all the users within the beam/channel, rather than the worst-case single user propagation margin, is the only important measure when determining the extra power required to overcome propagation impairments.

Call Set-Up Delay: AMSC's discussion of call set-up time is an obvious attempt to divert attention from the fundamental problem of signal delay in GSO systems. The RAS-related delay problem, resulting from the need to perform position fixes prior to setting up a call, is totally independent of whether the system is a GSO

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[1] Economic and Technical Considerations of a GSO Global MSS (Tritium), Pacific Telecommunications Conference, January 12-15, 1992, Honolulu, Hawaii, Hrycenko et al.

or non-GSO system. The use of GPS to provide the MES position information could be used to overcome this delay. Alternatively, the use of beacon RAS protection zones would avoid any delay due to this effect anyway.

Signal Delay: AMSC's claims about signal processing delays of non-GSO CDMA systems are totally unsubstantiated, and in TRW's opinion it is over-conservative in its estimation of the magnitude of the delay. However, putting AMSC's incorrect assumptions about the delays aside for a moment, the following points are important:

* The majority of the delay estimated by AMSC seems to be related to the CODEC performance. It is inevitable that the more voice coding applied, the more delay is introduced. The use of voice coding is fundamental to the success of all types of wireless voice communications systems (e.g., PCS, MSS). Therefore the argument that the delay is somehow due to the use of non-GSO satellites, or even due to the use of CDMA (which incidentally is proposed as the preferred access scheme in the AMSC's Exhibit B), is not correct. Are we to conclude that AMSC does not intend to use voice coding schemes that introduce any significant delay? If so, then its spectral efficiency will likely be that much worse than already predicted.
* The inevitable logic of the above argument is that AMSC will experience similar signal processing delays, due to the use of a voice compression algorithm, in addition to their propagation delay, resulting from the use of the GSO. The total signal delay in their system will therefore be significantly worse than any type of GSO FSS communications system currently in use. Subjective

tests performed in the past (when defending the Intelsat system against the competition from long-haul terrestrial communications technologies) have shown that users, while able to cope with the "human protocol" required to communicate on a system with GSO delay, find any additional delay very objectionable, and experience difficulty in communicating effectively without constant mutual interruptions. This could mean that AMSC's GSO system, which has both propagation delay and processing delay, will be unacceptable to users in this respect.

Acceptability of Signal Path Delay: AMSC's Exhibit B suggests that users will have no other communications alternative and so will not object to the delay from GSO. If true MSS competition exists with some of the service providers using non-GSO systems, then the users will have a choice, and will choose not to use systems that provide inferior service.

Effective coverage areas: AMSC criticizes non-GSO systems as having less effective coverage that a GSO system. This is not the case. By contrast, the ODYSSEY system achieves significantly higher average elevation angles to the latitudes of greatest interest than any GSO system. Even in the worst case, ODYSSEY does not need to operate at angles much lower than the constant elevation angle seen from regions in the 40 to 60 degree latitudes (large parts of North America and Europe) to GSO orbits. Furthermore, GSO systems cannot provide redundant signal paths (alternative satellites serving the same user), without significantly higher cost. This reduces their ability to provide a high level of service in many propagation environments.

Reliability and Sparing: Although AMSC claims that it has a fully redundant on-station backup satellite, it is questionable whether this satellite will remain in standby only, or will carry traffic simultaneously with the prime satellite. If it carries traffic then there will be a loss of service to some users in the event of a catastrophic satellite failure. Also, in AMSC's Exhibit B it is assumed that four in-orbit satellites would be used to provide three operating orbit locations. In such an operating scenario, a failure of a single satellite may involve having to re-locate the spare satellite by as much as 120°, which could take many weeks or months, depending on the amount of station keeping fuel used for the maneuver. This will delay the restoration of service to the users. By contrast, in many of the proposed non-GSO constellations, dual satellite coverage exists, which provides built-in redundancy in the event of a catastrophic satellite failure.

Orbit Debris: The arguments used by AMSC against non-GSO systems because of the orbit debris problem are certainly not justified in the case of ODYSSEY. The ODYSSEY orbit altitude of around 10,000 km has been very little used in the past and the amount of debris there is relatively small compared to GSO orbit altitudes, where the AMSC satellites will be located. Furthermore, ODYSSEY satellite fuel budgets allow for removal of end-of-life ODYSSEY satellites to a "graveyard" orbit to minimize the chance of future orbit collisions.

Feeder Link Interference with FSS: AMSC makes several arguments on this topic which are addressed below:

* AMSC cites a recent US contribution to ITU-R Task Group 4/5 (reference 5 in AMSC's Technical Appendix) as concluding that FSS allocations will be unusable for MSS feeder links. This is

not the case. This reference, which refers only to FSS allocations below 15 GHz, merely considers the time intervals when potential interference might exist, and compares this against allowable FSS outage requirements. AMSC is making the incorrect assumption that all cases of potential interference (i.e. FSS-MSS earth-space station alignment) will produce actual interference. Many techniques exist, which have been documented during the NRM, which can be used to mitigate the interference during such times of alignment, so that no unacceptable interference occurs. This fact completely invalidates AMSC's gross assumptions on this matter.

* At Ka-band, there is little FSS utilization and MSS feeder links can be accommodated. The LMDS service referred to by AMSC does not plan to make use of the same Ka-band frequencies that ODYSSEY is planning to use for its feeder links, and so no potential direct conflict in this area exists for ODYSSEY.
* AMSC considers that MSS proponents will not be able to obtain new frequency allocations specifically for MSS feeder links. ODYSSEY is not requesting dedicated spectrum for its feeder links, and is prepared reasonably to share its feeder link spectrum with non-MSS users. Additional work on the sharing of feeder links for systems using CDMA access schemes seems feasible, providing yet further potential for conservation of the feeder link spectrum.
* AMSC does not address the difficulty in finding FSS spectrum for its GSO-based feeder links. By definition, any GSO MSS system will be competing for feeder link spectrum with nearby FSS

satellites for 100% of the time, and not just the occasional instance of MSS-FSS alignment. The domestic and international GSO arcs are very crowded at both C and Ku-band FSS frequencies and very little opportunity exists to find any conventional FSS spectrum for such GSO MSS feeder links.

* AMSC states that the requirements for MSS feeder links are such that sharing with other services is more difficult than conventional FSS sharing with those other services. This is not the case. An MSS feeder link requirement is a subset of a general purpose FSS link requirement. The important distinguishing aspect is that MSS feeder links do not need to employ very small earth stations, as the relatively high complexity of an MSS gateway, and relatively small number of these gateways, are such that larger gateway antennas can economically be used. This significantly reduces the sharing problems with a wide range of other services, because of the high gain gateway antenna, and low spectral densities of its off-axis emissions. Furthermore, ODYSSEY has yet another important advantage in this respect as it does not need to operate at such low elevation angles as other non-GSO systems, and hence the gateway earth station coordination vis-a-vis geostationary FSS systems becomes significantly simpler.

* AMSC is very premature in concluding that reverse band working for MSS feeder links will not be feasible because of interference into other, non-FSS services. The current proposals in ITU-R Task Group 4/5 are aimed at exploiting the peculiar characteristics of MSS feeder links (i.e., small number of large gateway earth stations with considerable flexibility in their location) in order to

maximize the scope for coordination with other co-frequency services. The results so far appear encouraging and should be pursued to their conclusion. The results from the recent international meeting of this Task Group (June 2-10, 1994) will give further indication of the prospects of successfully using the reverse band technique for MSS feeder links.

* As AMSC points out, the use of feeder link earth station diversity is one technique to mitigate interference between MSS feeder links and FSS systems. AMSC criticizes this approach as being too costly, and creating a high density of feeder link earth stations. This is not the case in the ODYSSEY system because the relatively high satellite altitude (compared to LEOs) allows full service over the coverage areas to be achieved with only a very small number of feeder link earth stations. Additional feeder link earth stations will be needed to provide path diversity to combat localized rain fades and these could simultaneously be used to provide the spatial diversity necessary to overcome potential interference with FSS systems. Therefore there would be no additional cost burden associated with providing for the latter technique.

<u>ISM Interference</u>: AMSC's comments regarding ISM interference are a terrible indictment on its proposed GSO MSS system, assuming that it would also seek to make use of the 2483.5-2500 MHz band. The only distinguishing feature between non-GSO MSS systems and the proposed AMSC GSO system in this respect is that AMSC intends using mobile earth stations (MES) with significantly higher antenna gain than the non-GSO systems. These higher gain MES's can only be practically

implemented with vehicular based antennas. This is an admission that AMSC never intends to develop its system to the point where it might be able to offer hand-held service, contrary to what is suggested in the AMSC Exhibit B which discusses a futuristic GSO MSS system (Tritium) which uses 55 foot satellite antennas to achieve the required satellite gain to support hand-held MES. Considering that, in the light of the recently published information about the ISM interference environment (LQP and TRW - see below), the 2483.5 to 2500.0 MHz band is capable of sustaining this important new hand-held service, it is again obvious that this band should not be squandered on the 1980's technology of GSO based MSS systems, but rather should be reserved for the non-GSO systems that can provide true hand-held world-wide service.

FS Interference: In its discussion of interference into the Fixed Service, AMSC omitted to point out why the problem will be any less for GSO MSS systems. One could be left with the impression that AMSC is discouraging the use of any of the new subject bands for any MSS application. Regarding the MSS downlink case, specific inaccuracies in AMSC's comments include the assertion that all the current non-GSO system designs exceed the current FS coordination threshold PFD in all countries, and will therefore need to coordinate with each individual FS system. This ignores the inherent flexibility in systems such as ODYSSEY, which can control PFD on the earth's surface as a function of elevation angle by independently controlling beam loading in each of its beams. In addition, ODYSSEY operates at higher average and higher minimum elevation angles than many LEOs or GSOs, which further alleviates this problem. Current simulation studies in this area will be used to demonstrate how these advantages may be used to maximize the sharing between MSS and FS systems in the same band.

Swedish Radar: AMSC's explanation of the problems caused to non-GSO MSS systems by the Swedish radar systems is not applicable to ODYSSEY, again because of the use of much higher elevation angles in the ODYSSEY system, which make it appear more like a GSO system in this respect.

Futuristic Technology Requirements of GSO MSS Systems: AMSC's Exhibit B highlights at least two areas where highly advanced communications payload technology would have to be incorporated into a GSO MSS system if it was to be capable of providing a hand-held service. The first of these is the 55 foot diameter antenna, which completely dominates the spacecraft configuration. Such an antenna has never been flown commercially and the costs and risks of doing so, in the next twenty years or so, will be immense. The second critical item highlighted in AMSC's Comments is the constant efficiency SSPA. This "panacea" for the satellite designer has always been high on any wish-list, but despite much work on the subject, it has not been possible to implement a unit with anything like the required operating bandwidth. As for the antenna requirement discussed above, the constant efficiency amplifier will, in the most conservative estimate, be many years in coming to fruition. From a brief assessment of these two technology areas alone it is clear that GSO aspirations to provide efficient and economic hand-held MSS service are many years from being implemented, if ever.

Contrast Between AMSC's Plans and Tritium MSS Design: It is very surprising to find Exhibit B in AMSC's Comments, as the views presented in it are in such stark contrast to the views in AMSC's Technical Appendix. Specifically these differences are:

* In the Technical Appendix much criticism is placed upon the use of CDMA in the majority of the proposed non-GSO MSS systems. A completely contrary view is presented and justified in AMSC's Exhibit B, which concludes, without doubt, that CDMA access techniques are the only way to achieve the required spectral efficiencies and hence economic viability in their GSO-based Tritium design.
* The Tritium design -- if it could be built -- described in AMSC's Exhibit B is for a world-wide MSS system capable of providing hand-held service. AMSC shows no intention of even evolving their system towards this goal, but rather seems firmly entrenched in the prospect of building yet another USA domestic-only MSS system capable of communicating at best with vehicular mounted antennas, and with no prospect of ever offering true hand-held service.

3. Spectrum Allocation in the 2483.5-2500 MHz Band

TRW fully supports LQP's technical arguments in their Comments which explain why the Commission should allocate the entire 2483.5-2500 MHz band on a full-band interference sharing basis to the CDMA MSS operators. This is consistent with previous comments filed by TRW. In this regard, it should be noted that there is no rationale to support allocating to CDMA systems only the same amount of S-band spectrum as there will be L-band spectrum. Unlike conventional FDMA systems, CDMA systems do not require matched spectrum in the outbound and return link frequency bands, because of the co-channel operation of the CDMA links. Extra spectrum at S-band will be extremely useful, and will help to reduce the maximum PFD and hence ameliorate the potential interference with the FS.

4. GLONASS In-Band Issues

TRW disagrees with LQP's assessment that the Glonass issue is essentially "just a matter of coordination". In any coordination, not all the objectives at the outset are necessarily successfully achieved and the outcome is never clear until the coordination has been completed. From the unfolding story of the Glonass issue which is reported at the regular State Department meetings on this matter, it is very clear that most of the US government representatives are less than confident of a favorable outcome to the Glonass problem, in particular concerning the timescale of any resolution of the problem. It is therefore absolutely essential that a workable contingency plan be put in place until the outcome is clear.

TRW agrees with the FAA and ARINC views of the necessity of an interim Glonass plan because the movement of Glonass to frequencies below 1610 MHz is not a certainty at this time, even though there is unanimity concerning its desirability. However, we would stress again the importance of obtaining rapid resolution of this problem, so that appropriate plans can be made with a clear knowledge of the availability of spectrum.

TRW also questions why the FAA, in its Comments, totally ignores the US government proposal to move the Glonass operating frequencies down to the "± 6 plan" (i.e., using only Glonass channel frequencies corresponding to $-6 < k < +6$). This is the ideal solution to the Glonass problems, as it would also provide the required guard band in the range 1605-1610 MHz. This topic is the subject of extensive test and measurement by the US government at this time to determine if there is any possible interaction between Glonass and GPS with such a frequency plan.

In the absence of any clear resolution of the GLONASS issues at this stage, it is imperative that the FCC's rules reflect the current status of the ITU Radio Regulations regarding the maximum uplink EIRP spectral density limit. As agreed at WARC-92, and at the request of the Russian Administration, this limit is currently set at -15 dBW/4 kHz. There is absolutely no justification for changing this value at all at this stage. Only by maintaining this value will the U.S. Government be able to highlight to the Russian Administration that it intends to license MSS systems that will operate up to this power level. This can only help in bringing the required pressure to bear to bring about the GLONASS frequency plan changes that are necessary to allow MSS systems to operate in these bands.

5. Fixed Service Sharing

It is important to realize the significant FS coordination advantage that ODYSSEY possesses by virtue of its high elevation angles. LQP, in requesting a higher PFD threshold in its Comments, provided data concerning the reduction in its system capacity as a function of allowable PFD (Technical Appendix, Section 1.2, page 5). From this data it can be seen that Globalstar's capacity reduces to 81% of its maximum value when the PFD limit at low elevation angles is reduced by 3 dB. In the ODYSSEY system, such a change in low elevation angle PFD produces negligible impact on capacity, because the vast majority of users are operating with elevation angles far in excess of 25°. This phenomenon will allow ODYSSEY to operate much more compatibly with the FS than any of the other proposed non-GSO MSS systems.

TRW agrees with LQP concerning the use of the most prevalent form of FS system - the analog type - when assessing interference from the MSS downlinks. Use of the digital FS system as a baseline from which to assess acceptable interference from the MSS downlinks, will overly constrain the MSS operating PFDs and may result in the MSS systems being no longer economically viable. This is the position that TRW will be adopting in ITU-R TG2/2 and we consider it paramount that the US government supports it.

6. Out-of-Band Emissions from MSS

Protection of the FDMA/TDMA Portion of MSS Spectrum

Motorola's analysis of interference into Iridium[2] from CDMA uplinks operating in adjacent spectrum is inappropriate and inaccurate in the case of ODYSSEY uplinks, and the results are completely invalid. There are several important points to make in this context before any detailed calculations are performed.

Interference from Primary CDMA Uplink Into Secondary MSS Downlink

Firstly, the interference calculations performed by Motorola, if accepted as valid, result in an almost impossibly stringent requirement on the CDMA mobile transmitters to reduce the level of their emissions outside of their occupied bandwidth. Such a filtering requirement is totally incompatible with the use of low-cost handsets, especially, for those CDMA systems that utilize the widest spread bandwidths. The inevitable result of adopting Motorola's calculated out-of-band emission mask would be the need for an additional guard band between the CDMA and non-CDMA segments of the band. Such gross inefficiency was pointed out to the MSS Above 1

2 Comments of Motorola Satellite Communications, Inc. in CC Docket No. 92-166, May 1994.

GHz Negotiated Rulemaking Committee when the many disadvantages of a band segmentation approach were discussed during the NRM. If such a guard band is in fact needed, then it must be Motorola that carries the burden -- one created by its own design -- by providing this guard band from the portion of spectrum assigned for exclusive FDMA/TDMA use.

Secondly, Part 1 of the Technical Appendix in Motorola's Comments provides an analysis of the interference into Iridium's primary uplink and secondary downlink. The latter is found (by Motorola) to be the most constraining in terms of the out-of-band emissions of the CDMA mobile transmitters. However, claims of interference into Iridium's <u>secondary</u> downlink cannot be used to create any constraint on the primary uplinks of the CDMA MSS systems. Motorola's contrived example incorporating an aeronautical Iridium receiver, hiding under the auspices of a bona fide AMSS(R) service, is nothing more than an attempt to provide protection to their vulnerable secondary downlink. It is now apparent that the use of such a secondary downlink is highly problematic, not only due to the interference it causes to primary uplinks but also to its high sensitivity to interference from those primary uplinks. The use of frequency band and geographic region segmentation, as proposed by Motorola to overcome these fundamental defects in its system design, apparently will not solve these fundamental interference problems. No CDMA applicant can properly be required to accept any constraints on system operations in order to protect Motorola's <u>secondary</u> downlinks.

<u>Interference From CDMA Uplinks Into Iridium Uplinks</u>

The following analysis addresses only the issue of potential interference from CDMA uplinks (ODYSSEY only is considered here) into Iridium uplinks. It is shown that no additional out-of-band filtering of the CDMA signals should be required to protect the Iridium uplinks when operating in the adjacent frequency band. The derivation and full explanation of Equation [1] in Motorola's interference analysis is not provided in its Comments. Furthermore, it is not apparent how the results given in Motorola's Table 2 are derived from the parameter values given in Motorola's Table 1. For these reasons, the following analysis takes a much simpler approach, with a full explanation of each step in the analysis.

The first step is to calculate the aggregate uplink EIRP spectral density from the ODYSSEY mobile transmitters which will be received in a single beam of the Iridium satellite. Because of the statistical uncertainty in the numbers and locations of the ODYSSEY mobile transmitters, and the actual operating power level of each of them due to the use of power control, this part of the analysis when performed in certain ways can be rather subjective and statistically uncertain. In order to overcome this uncertainty, it is useful to refer to the analyses presented in the NRM[3] regarding the uplink channel capacities of the various CDMA systems as a function of the aggregate uplink EIRP aerial-spectral density (EIRP-ASD). The capacity curves for the ODYSSEY system derived in the NRM analysis are repeated below:

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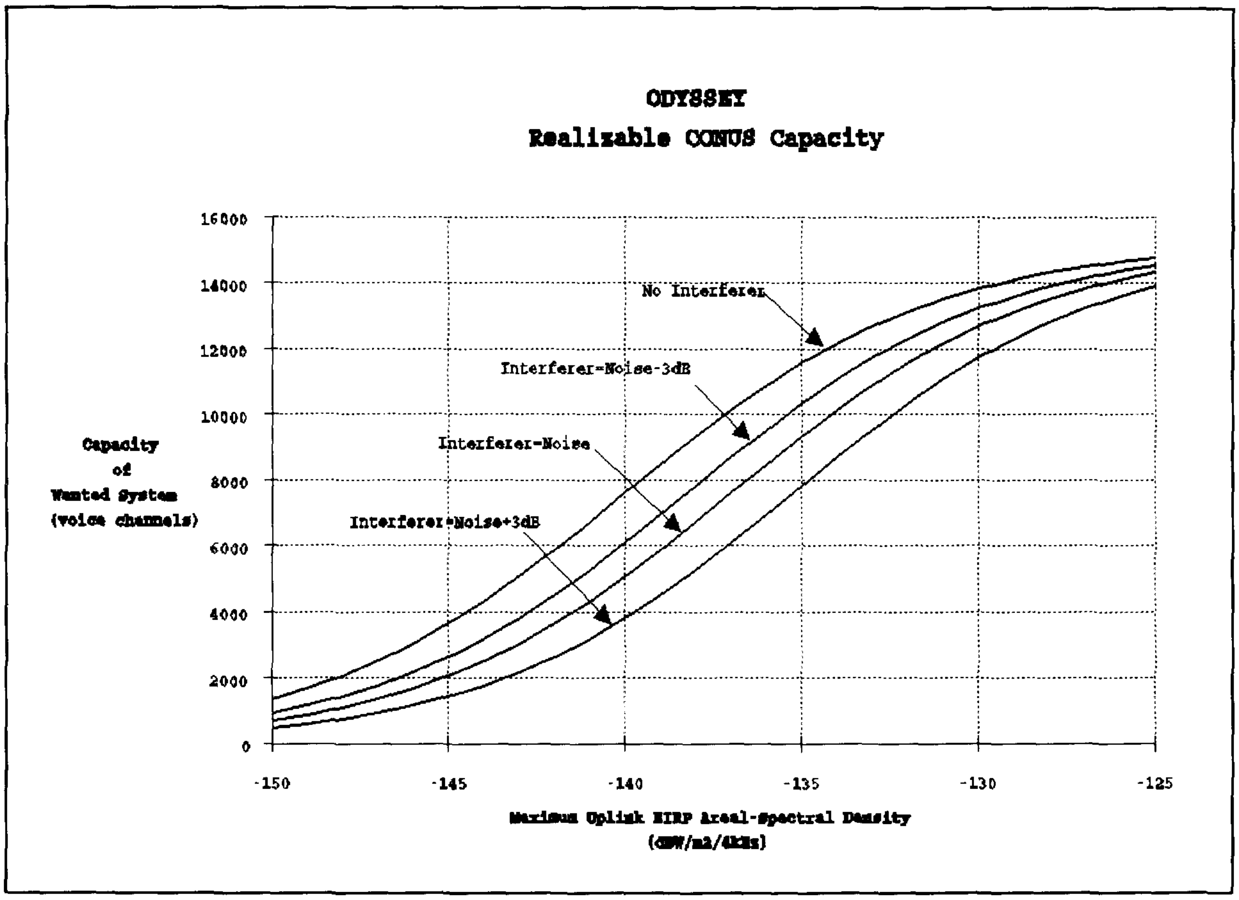
3 Report of the MSS Above 1 GHz Negotiated Rulemaking Committee; April 6, 1993.



Note the S-shaped capacity curve which is characteristic of both uplinks and downlinks of CDMA systems. This shape means that there is a fundamental limit to the capacity, and hence to the maximum useful value of EIRP-ASD. Operation near to the top of the S-shaped curve leads to power inefficiencies which are undesirable from the system operator's point of view. Operation above the value of

-130 dBW/m²/4kHz would be highly undesirable for this reason, as it is very near to the top of the curve. Operation above this value would be unnecessary anyway as this value gives more than sufficient channel capacity for the economic operation of the system. The following analysis assumes that this value of EIRP-ASD is the maximum used by the ODYSSEY system.[4]

Before continuing with the interference analysis it is useful to "calibrate" the above assumption of EIRP-ASD against some actual system operating parameters in order to demonstrate the applicability of the values used. Each ODYSSEY mobile transmitter will be capable of radiating a maximum EIRP of around 0 dBW. However, due to the use of uplink power control which minimizes the actual ODYSSEY mobile transmitter power, depending on propagation conditions in the mobile-to-satellite path, this value of EIRP will not be used simultaneously by all ODYSSEY mobiles. A typical scenario might involve 200 ODYSSEY mobiles within an ODYSSEY beam operating at an average EIRP 5 dB lower than the maximum, creating an aggregate uplink EIRP of +18 dBW. As these transmissions will be spread over an occupied bandwidth of 5 MHz, the resulting aggregate EIRP spectral density will be -13 dBW/4kHz. Assuming the ODYSSEY beam footprint area is 500,000 km2, then the average EIRP-ASD would be -130 dBW/m^2/4kHz. This is completely consistent with the derivation of maximum uplink EIRP-ASD derived above using the CDMA capacity curves.

Assuming that the maximum area of the footprint of an Iridium beam is 445,000 km^2,[5] then the maximum aggregate EIRP within the Iridium receive beam is derived from the above value of EIRP-ASD, as follows:

$$EIRP_{MAX} = -130 + 10\log(445{,}000e6) = -13.5 \text{ dBW/4 kHz}$$

4 Note that very similar values for maximum uplink EIRP-ASD can be derived for all the other CDMA applicants' systems, as is shown in the Report of the MSS Above 1 GHz Negotiated Rulemaking Committee; April 6, 1993. Note also that in the situation of multiple CDMA systems in operation, the aggregate uplink EIRP-ASD of all the systems will also not exceed this value, as this corresponds to near "saturation" of the spectrum.

5 Motorola/Iridium System Characteristics (Rev 2/11/93) presented during the NRM gives a range of beam footprint sizes from 216,000 km^2 to 445,000 km^2.

The Iridium signal itself is quoted by Motorola in its Comments as having an EIRP spectral density of -3 dBW/4kHz, with an assumed flat spectrum across its occupied bandwidth. For this reason the calculation of C/I can be made from the relative EIRP spectral densities (per 4 kHz). In the case of the given Iridium value of -3 dBW/4 kHz, the worst case of co-channel C/I is +10.5 dB, resulting in only a 0.4 dB loss of Iridium's link margin. In situations where the Iridium uplink signal is faded, while the interferer is not, the Iridium received C/I will be worse than this calculated value, by the amount of the Iridium signal fade. Note, however, that these are co-channel values, assuming that Iridium and ODYSSEY are operating at the same uplink frequency, and adjacent channel values will be much better, as discussed below.

When the ODYSSEY system and Iridium system operate in adjacent frequency bands, there will be additional isolation to consider when calculating interference from ODYSSEY uplinks into Iridium uplinks, due to the roll-off of the ODYSSEY signal spectrum. Assuming that Iridium accepts a 1 dB link degradation due to this interference,[6] then this corresponds to a C/I ratio of 7 dB. Assuming also that Iridium requires a 16 dB fade margin, as has been suggested in the past, then an unfaded C/I value of 23 dB would be required. This is 12.5 dB higher than the co-channel value calculated above. This level of performance would therefore be reached provided that the 1st modulation sideband[7] is 12.5 dB below the in-band value. Motorola's indicates that this sideband would be typically 25 dB below the in-band value (TRW does not necessarily concur with this value provided by Motorola), and so there is ample margin (12.5 dB) without any need for additional out-of-band filtering of the ODYSSEY emissions.

Although there is ample margin in the above analysis, TRW believes that, in this level of ODYSSEY/Iridium interference analysis, it is not necessary to include contribution from the Iridium beam spillover areas for the following reasons. Firstly, for

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6 This value is proposed in the Technical Appendix to Motorola's Comments, Part 1, Page 6.

7 Referred to in Motorola's Technical Appendix, Figure 1, as the 1st Plateau Isolation.

spectral efficiency reasons, the Iridium system has major requirements to re-use frequencies in beams spaced as closely as possible to each other, and to achieve this level of performance requires a steep beam roll-off characteristic. Thus the effect of interfering uplink EIRP from areas outside of the main Iridium footprint will be attenuated by the roll-off characteristics of the Iridium beam contours. Secondly, the worst-case beam footprint size (445,000 km^2) was used in this analysis, which corresponds to near-horizon beams operating at low elevation angles. In this case, there is a greater probability on average of the interfering uplinks also being attenuated by line-of-sight obstructions towards the Iridium satellite.

Protection of GLONASS

TRW strongly disagrees with the FAA proposal that the out-of-band specifications on the MES emissions be changed from a per-MHz to a per-4kHz unit in order to protect GPS and Glonass. This would be particularly onerous and unnecessary for wideband CDMA systems when the out-of-band specification is referring to adjacent frequency bands, due to the relatively slow spectrum roll-off of the CDMA signal. The issue of narrow-band spurs, which is the concern of the FAA in proposing this change, can be adequately addressed by an additional discrete spurious emission requirement, as is currently proposed in 25.213(b).

While TRW agrees in principle with ARINC that there will need to be an out-of-band specification on MES emissions in the event that Glonass changes its frequency band, it is not clear at this time what that specification should be for two reasons. Firstly, the current US measurements of GPS and Glonass susceptibility to interference from MES transmitters has not been completed, and to specify a value in the rules at this stage is premature. Secondly, TRW believes that ARINC is incorrect in stating that MSS must protect Glonass as a stand-alone system. The only foreseen application of Glonass in the USA is as part of GNSS, as explained by ARINC in its comments. It is therefore only necessary to protect Glonass to the point that the system level integrity of GNSS is preserved, which may be considerably less burdensome than protecting the individual Glonass system. This opinion is in line with the Comments of LQP and other Commenters in this proceeding. For this reason, TRW cannot accept that the MES EIRP spectral density value computed by ARINC during the NRM, and reiterated in ARINC's comments, is the appropriate value to use.

Protection of GPS

TRW notes that the FAA, in its Comments, is proposing a relaxation in the MES out-of-band EIRP spectral density limit, in order to protect GPS, from the value of -70 dBW/MHz in the proposed rule 25.213(b) to a value of -68 dBW/MHz, based on analyses performed by the aviation community since the NRM. The FAA, however, provides no explanation or justification for its suggestion that the GPS protection band should be increased to 20 MHz wide instead of the 2.046 MHz agreed to during the NRM. Rockwell International Corporation, in its Comments, suggests widening this protection band still further to 50 MHz, simply to permit a wide-band front-end on receivers intended to be used with both GPS and Glonass. Such a drastic increase in the protection requirements cannot possibly be accepted on this basis. The current US government sponsored research is underway to determine the actual sensitivity of GPS to MES emissions, and when the results of this are available, it will be possible to determine appropriate GPS protection levels and frequency bands.

Regarding ARINC's views on the out-of-band emission limit on MES transmitters to protect GPS, TRW again considers it premature to consider the values derived during the NRM as the appropriate ones. The current US government measurements of GPS susceptibility to interference are being performed with the aim of establishing correct protection levels for GPS, and the results of these tests should be available before any values are adopted in the rules. From discussions with those involved in the currently planned ECAC tests related to GPS, it is now apparent that even the DoD community feels that the existing sensitivity specifications of GPS receivers may be somewhat pessimistic. The belief that actual GPS receivers are able to withstand higher levels of interference than specified, without system failure, is one of the reasons for embarking on the ECAC tests. We are confident that these ECAC tests will demonstrate this to be the case and so permit the Commission to accept LQP's proposed rule change in 25.213 (b) regarding the allowable out-of-band power density to protect GPS (which relaxes the out-of-band level by 20 dB).

7. Out-of-Band Emissions Interfering with MSS

ISM

It is noted that the results of the recent ISM interference measurement campaign of LQP are encouraging, concluding that ISM interference will occur only a very small percentage of the time, even in urban environments. TRW has just completed its own independent ISM interference measurement campaign, and reports similar conclusions to those of LQP. A summary of the results of these TRW measurements is given in Attachment 1 to this Technical Appendix. Despite these very encouraging results, we would still urge the Commission to continue to take an interest in the emission performance of ISM devices that are being manufactured and brought into operation in the USA. Although the current ISM interference situation is acceptable, it is important to ensure that ISM manufacturers do not make changes to their equipment in these respects which might increase the level of interference into communications systems, such as MSS, that operate on adjacent frequencies.

ITFS/MDS

LQP's analysis and conclusions on the issue of potential interference from ITFS/MDS were based on the use of narrow (1.25 MHz) CDMA channels only. They concluded that interference into the highest frequency CDMA channel may be a problem but that their Globalstar system would then automatically assign a lower frequency channel to the affected MES. Such a situation may not be so straightforward with MSS systems employing wider CDMA channels (e.g., 5 MHz and above), as they may not have the flexibility to move to a lower channel frequency, depending on the beam/channel re-use arrangement. TRW's own initial measurements of this interference mechanism has produced encouraging results (see Attachment 1 to this Technical Appendix), suggesting that there may not be a serious interference problem. However, further measurements are required to confirm that this is the case. Also, until such time as the MSS applicants have frozen their system designs, based upon the present rulemaking, the impact of this interference will not be certain, and therefore we must defer making a final judgement on this matter of potential ITFS/MDS interference must be deferred. TRW's original Comments on this matter still hold.

WCAI's Comments regarding the impact of ISM interference on the MSS operations is irrelevant and uninformed,[8] and should not be used to deflect focus away from the possible interference caused by out-of-band emissions from ITFS and MDS transmitters. To the contrary, if ISM interference does occur in some situations it will likely be at the lower end of the 2483.5-2500 MHz band, requiring the MSS link to be temporarily re-located towards the upper end of the band. In this case it would be necessary to preserve as much usable spectrum as possible at the top end of the band, and thereby minimize the out-of-band interference from ITFS and MDS transmitters.

In its Comments WCAI also requests additional information about the interference susceptibility of the MSS systems, so that it can assess the required suppression of its out-of-band emissions. TRW agrees with this approach but points out that this information cannot be usefully provided by all the MSS applicants until such time as a

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8 Further measurements of the ISM emissions in the 2483.5-2500 MHz band have recently been performed by LQP and TRW and are reported in these current proceedings. These provide evidence that the ISM interference will not be a major problem in the use of this band for MSS downlinks.

spectrum allocation/sharing plan is agreed to,[9] as this impacts the CDMA channel bandwidth and center frequencies, and therefore the interference susceptibility.

WCAI also raises the issue of the use of broadband repeaters in some areas which pass the entire 2500-2690 MHz band, and the use of multiple channels at a single site. If WCAI "actively participated in the MSS Above 1 GHz Negotiated Rulemaking Committee", as it claims in its Comments, one wonders why such new information about these systems is surfacing at this late stage. In order to address these, and possibly other little known facts about the ITFS/MDS systems in operation or planned for use in the USA, TRW proposes that an appropriate representative of the ITFS/MDS interests (which could be WCAI) provide all relevant information about these systems to allow the required interference analysis to be performed. Only then can the appropriate suppression of ITFS/MDS emissions, and the input filtering requirements of MES receivers be correctly determined.

TRW strongly disagrees with the WCAI interpretation that "Implicit in the NPRM is the recognition that use of the 2483.5-2500 MHz band is not essential to the future of MSS". Nothing could be further from the truth. This frequency band is the only currently available band that is able to provide the innovative new world-wide, hand-held MSS services from non-geostationary orbit. The suggestion that it may not be usable because the ITFS/MDS operations in adjacent frequency bands are unable (or unwilling) to provide the required out-of-band suppression of their transmissions is ludicrous. The ITFS/MDS allocation is only in frequencies above 2500 MHz, and it is incumbent upon the service to make sure that its operations do not cause harmful interference to services (such as MSS) that are lawfully operating in adjacent bands. Moreover, the ITFS/MDS service involves a relatively small number of fixed, relatively high cost transmitters, which could be made to be compliant with the necessary out-of-band specifications without incurring excessive costs. It is important to distinguish between the relative costs of suppressing out-

9 It is assumed that this will occur when the final rules for this MSS service are completed.